

Hybrid aortic arch repair

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Innovations in thoracic endovascular aortic repair techniques have enabled its incorporation in open procedures, resulting in a hybrid approach to aortic arch repair. The present study reported our experience with the hybrid technique in managing arch pathologies. Fifty-one patients underwent a hybrid repair of arch pathologies. 10 patients had urgent or emergency surgery, and 8 had previous abdominal aortic aneurysm repair; all were classified as high risk (ASA grade III or IV). Overall 30-day mortality was 9.8% (5/51). Hospital mortality was 30% (3/10) in urgent/emergent surgery and 4.90% (2/41) in elective cases. Ischemic stroke occurred in 11.8% (6/51) of patients, while 5.9% (3/51) experienced paraplegia. Endoleaks occurred in 8 patients, 6 of which were Type 1. Long-term patency rate was 96%. The hybrid technique is a safe, effective and less invasive alternative to open repair of arch pathologies, with comparable outcomes in high-risk patient groups. Patency rates and durability demonstrate the long-term potential of this technique.

Keywords: Hybrid; endovascular repair; aortic arch surgery



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Introduction

A recent analysis of a large series of open repair for arch pathology showed that peri-operative mortality and neurological deficits after open surgery ranged from 3-20% and 3-17%, respectively (1). The mean 30-day mortality and stroke rates of these series were 14% and 11%, respectively. Many of these series excluded high-risk patients which represent the majority of patients requiring intervention (2).

We have recently reported our experience with the management of vascular pathologies of the ascending aorta, aortic arch and proximal descending aorta using the hybrid technique (3).

Patients and methods

A prospectively maintained database of 51 patients (34 men, 17 women) who had hybrid repair was included in this study. A fifth of presentations were urgent or emergency, eight (16%) had previous abdominal aortic aneurysm repair

and all were high risk (ASA class III or IV). The majority presented with degenerative aneurysm or aortic dissection.

All bypass grafts were performed under general anesthesia. To achieve adequate proximal landing in Ishimaru zone (LZ) 0, four patients (8%) underwent complete arch debranching using a graft from the ascending aorta to the supra-aortic vessels. Twenty-three patients (45%) had a carotid-to-carotid artery bypass graft, and eight had carotid-to-carotid-to-left subclavian artery bypass grafts in order to provide proximal landing in zone 1. Sixteen patients had the left subclavian artery (LSA) revascularized using a carotid-LSA bypass graft.

Results

The overall 30-day mortality rate was 10% (5 of 51 patients); 5% (2 of 41 patients) in elective patients and 30% (3 of 10 patients) in urgent/emergency patients. Two urgent patients died from rupture; one from an aneurysm which occurred during the operation and one from chronic dissection at ten days post-operatively. Two fatal pulmonary

complications occurred from pulmonary embolism (day 3) and pneumonia (day 9). One patient died of unknown cause on day 20. Ischemic strokes were observed in six patients (12%) during the peri-operative period and no late strokes occurred. There were four posterior circulation strokes (3 had the left subclavian artery revascularized), one anterior circulation stroke and one lacunar stroke. Strokes occurred with more proximal aortic disease (one in LZ 0 and four in LZ 1 and one in LZ 2). The paraplegia rate was 6% (3 of 51 patients). Three retrograde aortic dissections occurred and one patient died.

There were eight peri-operative endoleaks, six of which were proximal Type 1. Three of the four patients with endoleaks detected on completion angiography died from pulmonary embolism (day 2), aortic rupture (day 10) and heart failure (3 months) before reintervention could be performed. The primary technical success was 86%.

Extra-anatomic bypass graft occlusion occurred in two patients in the perioperative period. This resulted in a long-term patency rate of 96%. One had a posterior circulation stroke on day 21. The second patient had right-sided hemiplegia on day 30.

Discussion

Thoracic endovascular aortic repair (TEVAR) in combination with extra-anatomic bypass grafting has provided an alternative option to treat aortic arch pathologies. This hybrid technique may give equivalent or better long-term outcomes for high-risk patients ineligible for surgical repair (2). However, the aortic arch is a technically difficult region for endovascular repair. The acute angulation and morphology of the arch makes creating an adequate proximal seal difficult and also predisposes to endograft collapse. While modern stent grafts have been designed to address these issues, endoleaks and stent graft migration continue to be a problem. Extra-anatomic supra-aortic debranching is required to maintain cerebral perfusion. Newer alternatives, such as branched stent grafts, may eliminate the need for extra-anatomic debranching, but their effectiveness remains to be confirmed by large scale, long-term studies. Until then, the hybrid technique remains an alternative option for high-risk patients requiring thoracic aortic repair.

However, there is little data on the long-term efficacy of hybrid operations. Antoniou *et al.* conducted a meta-analysis of hybrid supra-aortic debranching and stent graft repair (1). A pooled analysis of 275 patients showed a mean 30-day mortality rate of 15%, stroke rate of 8%

and paraplegia rate of 2%. Comparison of our neurological events is similar to those series with larger patient numbers; six patients had a stroke and five of these occurred in the elective cohort. These were probably the result of wire manipulation in an atheromatous aortic arch causing embolization to the supra-aortic vessels.

One area of contention regarding the hybrid technique is how to manage deliberate occlusion of the left subclavian artery with the endograft. Some have suggested that revascularisation of the LSA is necessary to prevent stroke. The rationale for this is that coverage of the LSA may cause posterior circulation strokes by vertebrobasilar ischemia and anterior circulation strokes by indirectly reducing Circle of Willis perfusion pressures. Others have reported that routine pre-procedural LSA revascularization does not confer protection against stroke and due to the inherent complications associated with revascularization and increased cost of an additional procedure, patients must be carefully selected for revascularization. We have previously reported that coverage of the LSA during TEVAR without prior revascularization significantly increases the risk for stroke (4). We did not routinely revascularize the LSA, such as in patients with small or absent left vertebral arteries or with a dominant right vertebral artery. Our absolute indications for LSA revascularization include patent left internal mammary artery for coronary artery bypass graft; small, occluded or absent right vertebral artery; dominant left vertebral artery; left arm arterio-venous fistula or patent left axillo-femoral bypass graft (4,5). In the present study revascularization of the LSA did not protect against stroke. Of four patients who had posterior circulation strokes, only one did not have their LSA revascularized. Moreover, LSA revascularization did not prevent an anterior circulation stroke in one patient who had a dominant right vertebral artery.

Endoleaks are unique to endovascular stent grafting and remain a major disadvantage compared to open surgery, with Type 1 and 3 endoleaks predisposing to aneurysm expansion and aortic rupture. These endoleaks contribute to the high reintervention rate and primary technical failures associated with endovascular repair. In their meta-analysis, Antoniou *et al.* found that 61% of primary technical failures were attributable to either Type 1 or 3 endoleaks. Throughout the study period, eleven endoleaks (peri-operative and late) were detected, resulting in an endoleak rate of 22%.

An important aspect of the hybrid technique is the long-term patency of bypass grafts. Occlusion or stenosis of a supra-aortic bypass graft can have catastrophic consequences such as upper limb ischemia, stroke and death. Unfortunately, patency rates are often under-

reported in studies involving the hybrid technique so little is known about their long-term durability. Only five of the thirteen hybrid series above reported on bypass graft occlusions, which ranged from 0-4%. This is in keeping with our study, where there were two graft occlusions (4%), resulting in a long-term patency rate of 96%. We have previously reported on supra-aortic bypass patency rates in a study comparing bypass grafting and angioplasty for atherosclerotic disease of the supra-aortic trunk (5). In that study bypass grafting had better patency rates than angioplasty of diseased supra-aortic vessels. After 19 years, only one of thirty-five grafts was occluded. These patency figures are promising and demonstrate the long-term durability of the hybrid technique.

In summary, we believe that the hybrid technique is a safe, effective and less invasive alternative to open surgery with comparable outcomes in a cohort of high-risk patients unfit for open surgery. Moreover, good long-term patency rates demonstrate the durability of this technique.

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